MONITORING MACHINE CONDITION
[ÜBERWACHUNG DES MASCHINENZUSTANDES]

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Description <u>/1</u>*

Definitions of terms

[0001] Terms that are used in this patent specification are explained in order to facilitate understanding.

[0002] Field devices:

Devices that are located in the field, therefore directly on the machine or in the machine/unit control cabinet. They require special design features because of the unfavorable environmental conditions. They differ from devices in the measuring stations or in the office area.

[0003] Measured vales, measured data:

are analogous values, as they are transmitted from the sensors to the field device. For example, a pressure value in the 0...30 bar range can be provided by the sensor as a measured value in the 0 - 20 milliampere range.

[0004] Single-process values/-data:

are digitized measured values, that were converted to their physical dimensions, for example, pressures in bar, temperatures in °C.

[0005] Calculated process values/data:

single process values often are not sufficient for detecting the machine state. Calculated process values must be calculated from single process values. Calculated process values are, for example, temperature differences, pressure differences, efficiencies, frequency spectra, torques.

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*Numbers in the margin indicate pagination in the foreign text.

[0006] Counting values, counting data:
are provided as pulses from the corresponding sensors. For the most part amounts that are calculated for operating data (throughputs, piece numbers, lengths...) are based on the counting pulses.

[0007] Digitized values, data:
are already digitized values, as are frequently provided by measuring devices, e.g. scales.

[0008] Switch value:
is the state of a function within a technological process. For example, a motor is switched on or off. Other states do not occur in the case of switch values. The frequency of the switch cycles as well as the switching time in relation to the running time are process values derived for the machine state.

[0009] Operating data:
as opposed to process data. They describe produced and transported media. The operating data are frequently obtained from numerical data and digitized values, such as weight values.

[0010] Statistical parameters:
these include average value, maximum value, minimum value, standard deviation, and variance.

[0011] The invention concerns a field device for acquiring measured, counted, and digitized data as well as switch values, that are provided by sensors and measuring devices, and provide information concerning the technological process and operating data.

[0012] The possibility of carrying out maintenance operations dependent on the state of the machine, has considerable advantages as compared with the usual methods of the time-dependent or plotting-speed-dependent intervals of maintenance operations.

[0013] For example, if maintenance measures are based on a specific number of kilometers driven by an automobile, such a determination does not take the actual state into account. The latter depends not only on the distance traveled, but on a plurality of further parameters, such as the speed driven, the state of the roads traveled, the care of the driver, the environmental conditions, such as temperature, atmospheric humidity, air pollution...

[0014] It is impossible to take account of all of these influencing factors in determining the maintenance intervals.

[0015] The term "state-oriented maintenance" has been introduced into the discussion. The advantages of a procedure of this kind are apparent. If the state of a unit is successfully determined, this has a positive effect on the availability and service life of a unit. Unpredictable downtimes with a high repair expense can be limited or entirely prevented. The availability of the units is clearly improved in this way.

[0016] According to the current state of knowledge there are still no methods available for detecting and evaluating the machine state or the state of a unit.

[0017] The difficulty in formulating generally valid information concerning the state of a machine/unit is based on the fact that the

basic technological processes of the machines/units are fundamentally different.

[0018] For example, in the case of a cooler or a heat exchanger, the reduction of the heat transfer is a basic measure of the required maintenance operations. This is shown by a reduction of the temperature difference between the input and output temperature. This can be produced by contamination, corrosion, or deposition in pile lines.

[0019] In the case of fast-running machines, such as turbines, the state of the bearings is an important measure of the overall state. This is expressed in vibrations that can be uses as criteria for required maintenance operations.

[0020] In the case of large diesel engines the exhaust temperatures of the individual cylinders in relation to the average exhaust temperature can be used as one of the criteria for the machine state.

[0021] The object of the invention is to make a generally valid determination of the state of a machine/unit in spite of different technological processes.

[0022] In accordance with the invention this happens in two sequential steps that take place in field devices corresponding to the invention.

[0023] In a first step, single and calculated process values are determined from the detected measurement, counting, and digitized values, as well as the switch values.

[0024] In a second step the statistical parameters are calculated and securely stored in the field devices.

[0025] Changes that are a measure of the state of the machine are found if the statistical parameters are chronologically sequences over a long time period.

[0026] It is now no longer difficult for an expert to determine the correct process data that provide information concerning wear, corrosion, deposits, contamination, aging, and performance reduction.

[0027] The statistical parameters thus obtained are now ready in the field devices, are securely stored, and can be read by higher-order computers. Secure is to be understood as meaning that the data also are not lost in the case of a current failure, and that the probability of failure is very little as a result of the design of the field devices.

[0028] In a further configuration of the invention, it is possible to define limiting values that produce the warning and shut-off signals, when specific limiting values of the statistical parameters are exceeded or not reached. For this the field devices according to the invention require additional switch outputs in /2 order to report the limiting value violations. Limiting value violations also can be reported to the higher-order computers via interfaces.

[0029] Aging and wear in general are not linear. After exceeding a specific state, the rate of changes increases. This can be defined

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as a criterion for an impending end phase. End phases of this kind can result in a crash with complicating consequences.

[0030] Thus it is advantageous to accurately observe changes in ascending gradient. Field devices can now be equipped with very high-performance processors, so that further functions can be integrated. For example, the process and operating values determined in the intermediate step could also be used in order to carry out current process monitoring. In addition, process automation procedures could be performed.

[0031] The field devices can also be single devices or modular systems, consisting of several devices, or one device with several slide-in modules.

[0032] A specific embodiment of the invention with reference to the Figs. 1 and 2 is described below.

[0033] Fig. 1 shows an industrial model of a typical field device that is suited for mounting on machines or in the control cabinet of a machine because of its design features.

[0034] 1 is a standard connection for an Ethernet data network. The jack 2 is provided for connecting a modem for remote data transmission. The clamp rows 3 and 4 are used for connecting the sensors.

[0035] Fig. 2 shows a schematic representation of a monitoring device.

[0036] 1 represents a machine/unit with a series of measuring points that are equipped with sensors. 8 indicates sensor lines. 2

and 3 are modular field devices. 4 is the schematic representation of a data network. 5 indicates higher-order PC's. 6 is the schematic representation of a remote data connection, for example via the telephone network. 7 is a remote PC.

[0037] The operation is as follows:
Fig. 1 shows a field device corresponding to the invention. The device is connected with a data network (Ethernet) via data terminal 1. In this way the device can exchange data with PC's. On the one hand such a device must be configured for a specific task. On the other hand, a PC can read the stored data and output the data in appropriate form on a screen and printer. Such a device basically only needs to be configured one time. The configuration data are permanently stored in the field device. Suitable software must be installed on the PC's provided for this. The international TCP/IP protocol is used for the data exchange. In this way complete compatibility with other processed in the data net is provided. Commercial data processing of a company can take place via the same network.

[0038] The jack 2 is a connection for a modem. In this way it is possible that a remote computer can communicate with the device via radio or telephone. It is also possible to exchange the data via Internet providers by means of the consistent use of the TCP/IP protocol with its sub-protocols.

[0039] The sensors are connected to the field device via the terminal connections 2 and 3. Globally the object of the device is to

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continuously detect the measured values provided by the sensors, to digitize the measured values, to continuously calculate the process data, and to determine and store the statistical parameters. Then these data are ready to be read by network PC's or via modem by remote PC's.

[0040] Fig. 2 schematically shows a data network of this kind, corresponding to the invention. The machine/unit 1 to be monitored contains sensors, that detect sensors, the different physical values, such as temperatures, pressures, speeds, ... These sensors are connected via the schematically indicated lines 8 with the field devices 2 and 3 corresponding to the invention.

[0041] The field devices 2 and 3 are connected with the PC's 5 vial the star-shaped data network 4, for example an Ethernet network. Thus the PC's 5 can read the data stored in the field devices 2 and 3, via the star-shaped data network 4.

[0042] Thus a remote PC 7 can also access the data of the field devices 2 and 3, such as the local network PC's 5 by means of the schematically drawn telephone connection 6. Remote PC's 7 of this kind can be used by experts for observing and analyzing the technological process of the machine/unit, without being present on site.

Patent Claims

1. A field device for detecting measurement, counting, and digitized data, as well as switch values, that continuously detects and (as much as possible) the data relevant for the state of a

machine/unit during the running time of the machine, wherein it continuously calculates from these data single and calculated process data as well as operating data and that calculates and stores the statistical parameters of these data during fixed time sections, and thus makes them available for further evaluations.

2. The field device according to Claim 1, wherein those process and operating data, that provide information concerning wear, corrosion, deposits, contamination, aging, and performance reduction, are calculated.

3. The field device according to Claims 1 and 2, wherein the statistical parameters can be transmitted to other data devices per data interfaces (field bus, data network, modem, or radio).

4. The field device according to Claims 1 to 3, wherein the statistical parameters are compared with limiting values and warning and/or shut-off signals are produces if these limiting values are violated.

5. The field device according to Claims 1 to 4, wherein the rat of the changes of statistical parameters (ascending gradient) can be used for comparison with nominal ascending gradients as criteria for crash prevention.

6. The field device according to Claims 1 to 5, wherein the field devices can assume other tasks within the process automation.

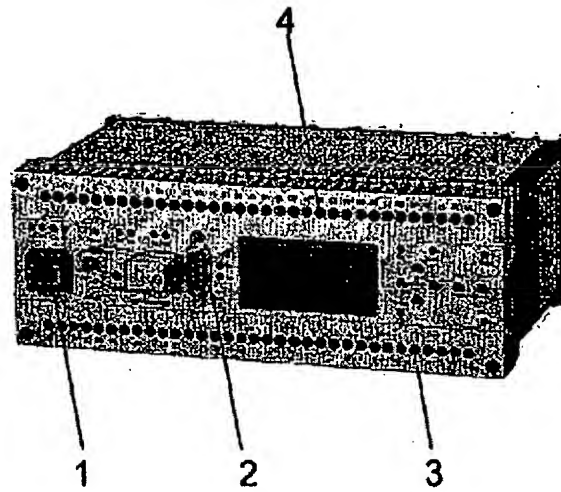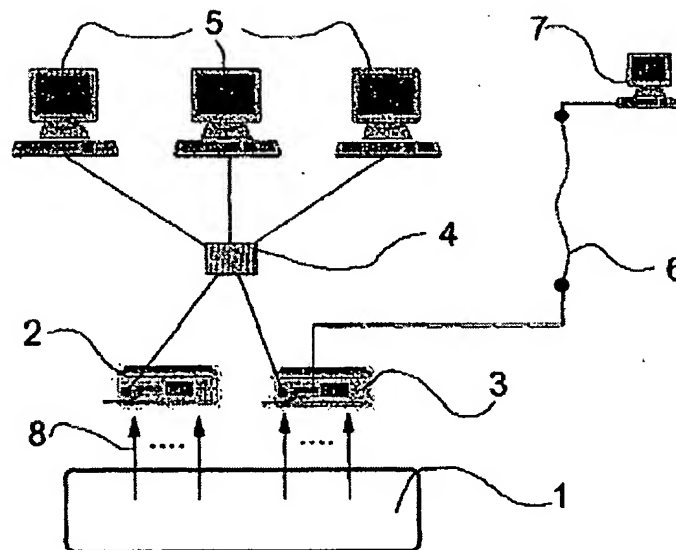---

1 page of drawings appended

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Fig. 1

Fig. 2